

**Final Report for Period:** 08/2009 - 07/2010**Submitted on:** 08/16/2010**Principal Investigator:** Tannenbaum, Allen R.**Award ID:** 0625218**Organization:** GA Tech Res Corp - GIT**Submitted By:**

Tannenbaum, Allen - Principal Investigator

**Title:**

Geometric Particle Filters for Visual Tracking (Attn. Dr. Kishan Baheti)

**Project Participants****Senior Personnel****Name:** Tannenbaum, Allen**Worked for more than 160 Hours:** Yes**Contribution to Project:****Post-doc****Graduate Student****Undergraduate Student****Technician, Programmer****Other Participant****Research Experience for Undergraduates****Organizational Partners****Other Collaborators or Contacts****Activities and Findings****Research and Education Activities:**

We have developed combined nonlinear estimation schemes with geometric active contours in 2008. This work has been presented at Yale, MIT, Harvard, UCSD, Indiana University, and the CDC, ACC, SIAM, and MICCAI conferences. Some of the material has been incorporated into a graduate level control course given at Georgia Tech.

**Findings:**

We combined unscented Kalman filtering, active contours, and shape based observers for tracking and image registration. This has been used for various purposes including magnetic resonance biopsy in prostate cancer. We can now track at about 50 frames per second which makes the algorithm practical for a number of applications.

**Training and Development:**

I have developed a course in computational computer vision at the graduate level at Georgia Tech to educate students about the techniques of active contour tracking. These methods are also being included in a graduate level course in medical imaging.

**Outreach Activities:**

I have given an interview in the Georgia Tech Magazine 'Research Horizons' in which my research will be highlighted.

**Journal Publications**

Y. Rathi and A. Tannenbaum, "A generic framework for tracking using particle filter with dynamic shape prior", IEEE Trans. Image Processing, p. , vol. 16, (2007). Published,

Y. Rathi, N. Vaswani, A. Tannenbaum, A. Yezzi, "Tracking deforming objects using particle filtering for geometric active contours", IEEE PAMI, p. 1470, vol. 29, (2007). Published,

L. Zhu, Y. Yang, S. Haker, A. Tannenbaum, "An image morphing technique based on optimal mass preserving mapping", IEEE Trans. Image Processing, p. 14, vol. 16, (2007). Published,

J. Melonakos, E. Pichon, A. Tannenbaum, E. Pichon, "Geodesic active contours in a Finsler metric", IEEE PAMI, p. 412, vol. 30, (2008). Published,

O. Michailovich, Y. Rathi, A. Tannenbaum, "Image segmentation using active contours driven by the Bhattacharyya gradient flow", IEEE Image Processing, p. 2787, vol. 16, (2007). Published,

O. Michailovich and A. Tannenbaum, "Fast approximation of smooth functions from samples of partial derivatives with applications to phase unwrapping", IEEE Signal Processing, p. 358, vol. 88, (2008). Published,

O. Michailovich and A. Tannenbaum, "Blind deconvolution of medical ultrasound images: parametric inverse filtering approach", IEEE Image Processing, p. 3005, vol. 16, (2007). Published,

D. Nain, S. Haker, A. Bobick, A. Tannenbaum, "Multiscale 3D shape representation and segmentation using spherical wavelets", IEEE Medical Imaging, p. 598, vol. 26, (2007). Published,

T. Georgiou, O. Michailovich, Y. Rathi, J. Malcolm, A. Tannenbaum, "Distribution metrics and image segmentation", Linear Algebra and Its Applications, p. 663, vol. 425, (2007). Published,

M. Niethammer, P. Vela, A. Tannenbaum, "Geometric observers for dynamically evolving curves", IEEE PAMI, p. , vol. , (2008). Accepted,

A. Wake, J. Oshinsky, D. Giddens, and A. Tannenbaum, "Choice of in vivo versus idealized velocity boundary conditions influences the flow field in subject-specific models of the human carotid bifurcation", Journal of Biomedical Engineering, p. , vol. 131, (2009). Published,

N. Vaswani, Y. Rathi, A. Yezzi, and A. Tannenbaum, "PF-MT (Particle Filter with Mode Tracker) with an interpolation effective basis for tracking local contour deformations", IEEE Trans. Image Processing, p. , vol. , (2009). Accepted,

E. Haber, T. Rehmen, and A. Tannenbaum, "An efficient numerical method for the solution of the L2 optimal mass transfer problem", SIAM Journal on Scientific Computation, p. , vol. , (2009). Accepted,

O. Michailovich, Y. Rathi, and A. Tannenbaum, "Dynamic denoising of tracking sequences", IEEE Trans. Image Processing, p. 847, vol. 17, (2008). Published,

J. Melonakos, E. Pichon, S. Angenent, and A. Tannenbaum, "Finsler active contours", IEEE PAMI, p. 412, vol. 30, (2008). Published,

Vaswani, Rathi, Tannenbaum, "PF-MT (Particle Filter with Mode Tracker) with an interpolation effective basis for tracking", IEEE Trans. Image Processing, p. , vol. 19, (2010). Published,

E. Haber, T. Rehman, G. Pryor, J. Melonakos, A. Tannenbaum, "3D nonrigid registration via optimal mass transport on the GPU", MedIA, p. 931, vol. 13, (2009). Published,

S. Dambreville, R. Sandhu, A. Yezzi, A. Tannenbaum, "A geometric approach to joint 2D region-based segmentation and 3D pose estimation", SIAM Imaging Science, p. 110, vol. 3, (2010). Published,

A. Dominitz and A. Tannenbaum, "Texture mapping via optimal mass transport", IEEE Trans. Visualization and Computer Graphics, p. 419, vol. 16, (2010). Published,

Y. Rath, J. Malcolm, S. Bouix, M. E. Shenton, A. Tannenbaum, "Affine registration of label maps in label space", Journal of Computing, p. 1, vol. 2, (2010). Published,

B. Gholami, W. Haddad, A. Tannenbaum, "Relevance vector machine learning for neonate pain intensity assessment using digital imaging", IEEE Trans. Biomedical Engineering, p. 1457, vol. 57, (2010). Published,

R. Sandhu, S. Dambreville, A. Tannenbaum, "Point set registration via particle filtering and stochastic dynamics", IEEE TPAMI, p. 1459, vol. 32, (2010). Published,

R. Sandhu, S. Dambreville, A. Tannenbaum, "A non-rigid kernel based framework for 2D/3D pose estimation and 2D image segmentation", IEEE TPAMI, p. 786, vol. 32, (2010). Published,

J. Lee, S. Lankton, A. Tannenbaum, "Object tracking and target reacquisition on 3D range data with particle filtering and online shape learning", IEEE Trans. Image Processing, p. , vol. , (2010). Accepted,

V. Mohan, G. Sundaramoorthi, A. Tannenbaum, "Tubular surface segmentation for extracting anatomical structures from medical imagery", IEEE Trans. Medical Imaging, p. , vol. , (2010). Accepted,

### **Books or Other One-time Publications**

S. Dambreville, Y. Rath, A. Tannenbaum, "Particle filtering with dynamic shape priors", (2006). Book, Published  
Collection: Lecture Notes in Computer Science {bf 4141}  
Bibliography: Springer-Verlag

S. Bouix, K. Siddiqi, A. Tannenbaum, and S. Zucker, "Medial axis computation and evolution", (2006). Book, Published  
Editor(s): H. Krim and A. Yezzi  
Collection: {em Statistics and Analysis of Shapes}  
Bibliography: Springer-Verlag

S. Dambreville, Y. Rath, A. Tannenbaum, "A shape-based approach to robust image segmentation", (2006). Book, Published  
Collection: Lecture Notes in Computer Science {bf 4141}  
Bibliography: Springer-Verlag

A. Dominitz, S. Angenent, A. Tannenbaum, "On the computation of optimal transport maps using gradient flows and multiresolution analysis", (2009). Book, Published  
Editor(s): V. Blondel, S. Boyd, and H. Kimura  
Collection: Recent Advances in Learning and Control  
Bibliography: Springer-Verlag

J. Malcolm, Y. Rath, A. Tannenbaum, "Label space: A multi-object representation", (2008). Book, Published  
Collection: Combinatorial Image Analysis  
Bibliography: Lecture Notes in Computer Science

T. Georgiou and A. Tannenbaum, "Sparse blind source deconvolution with application to high resolution frequency analysis", (2010). Book, Published

Editor(s): Hu, X.; Jonsson, U.; Wahlberg, B.; Ghosh  
 Collection: Three Decades of Progress in Control Sciences  
 Bibliography: Springer-Verlag

### Web/Internet Site

**URL(s):**

www.bme.gatech.edu/groups/bil

**Description:**

This site contains the work of my research group including projects supported by NSF.

### Other Specific Products

### Contributions

**Contributions within Discipline:**

The techniques have contributed to problem of using visual information in a feedback loop, the key problem in controlled active vision.

**Contributions to Other Disciplines:**

Our work has contributed to medical imaging.

**Contributions to Human Resource Development:**

**Contributions to Resources for Research and Education:**

The results have been useful in the development of visual tracking experiments at Georgia Tech as part of the computational computer course. They have also been used in the airborne laser missile tracking project.

**Contributions Beyond Science and Engineering:**

### Conference Proceedings

Niethammer, M;Zach, C;Melonakos, J;Tannenbaum, A, Near-tubular fiber bundle segmentation for diffusion weighted imaging: Segmentation through frame reorientation, "JUL 14-25, 2008", NEUROIMAGE, 45 (1): S123-S132 Suppl. 1 MAR 2009

Lankton, S;Malcolm, J;Nakhmani, A;Tannenbaum, A, TRACKING THROUGH CHANGES IN SCALE, "OCT 12-15, 2008", 2008 IEEE INTERNATIONAL CONFERENCE ON IMAGE PROCESSING, PROCEEDINGS, : 241-244 2008

Dambreville, S;Yezzi, A;Lankton, S;Tannenbaum, A, TAC: THRESHOLDING ACTIVE CONTOURS, "OCT 12-15, 2008", 2008 IEEE INTERNATIONAL CONFERENCE ON IMAGE PROCESSING, PROCEEDINGS, : 749-752 2008

Malcolm, J;Rathi, Y;Shenton, ME;Tannenbaum, A, Label Space: A Coupled Multi-shape Representation, "SEP 06-10, 2008", MEDICAL IMAGE COMPUTING AND COMPUTER-ASSISTED INTERVENTION - MICCAI 2008, PT II, PROCEEDINGS, 5242: 416-424 2008

Dambreville, S;Sandhu, R;Yezzi, A;Tannenbaum, A, Robust 3D Pose Estimation and Efficient 2D Region-Based Segmentation from a 3D Shape Prior, "OCT 12-18, 2008", COMPUTER VISION - ECCV 2008, PT II, PROCEEDINGS, 5303: 169-182 2008

Lankton, S;Melonakos, J;Malcolm, J;Dambreville, S;Tannenbaum, A, Localized Statistics for DW-MRI Fiber Bundle Segmentation, "JUN 23-28, 2008", 2008 IEEE COMPUTER SOCIETY CONFERENCE ON COMPUTER VISION AND PATTERN RECOGNITION WORKSHOPS, VOLS 1-3, : 365-372 2008

Sandhu, R;Dambreville, S;Tannenbaum, A, Particle filtering for registration of 2D and 3D point sets with stochastic dynamics, "JUN 23-28, 2008", 2008 IEEE CONFERENCE ON COMPUTER VISION AND PATTERN RECOGNITION, VOLS 1-12, : 3514-3521 2008

Sandhu, R;Georgiou, T;Tannenbaum, A, Tracking with a new distribution metric in a particle filtering framework - art. no. 68130N, "JAN 29-31, 2008", IMAGE PROCESSING: MACHINE VISION APPLICATIONS, 6813: N8130-N8130 2008

Sandhu, R;Georgiou, T;Tannenbaum, A, A new distribution metric for image segmentation - art. no. 691404, "FEB 17-19, 2008", MEDICAL IMAGING 2008: IMAGE PROCESSING, PTS 1-3, 6914: 91404-91404 Part 1-3 2008

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Malcolm, J;Rathi, Y;Yezzi, A;Tannenbaum, A, Fast approximate curve evolution, "JAN 28-29, 2008", REAL-TIME IMAGE PROCESSING 2008, 6811: U173-U180 2008

Lankton, S;Tannenbaum, A, Improved tracking by decoupling camera and target motion, "JAN 28-29, 2008", REAL-TIME IMAGE PROCESSING 2008, 6811: U310-U317 2008

Pryor, G;Rehman, TU;Lankton, S;Vela, PA;Tannenbaum, A, Fast optimal mass transport for dynamic active contour tracking on the GPU, "DEC 12-14, 2007", PROCEEDINGS OF THE 46TH IEEE CONFERENCE ON DECISION AND CONTROL, VOLS 1-14, : 6063-6070 2007

Melonakos, J;Niethammer, M;Mohan, V;Kubicki, M;Miller, JV;Tannenbaum, A, Locally-constrained region-based methods for DW-MRI segmentation, "OCT 14-21, 2007", 2007 IEEE 11TH INTERNATIONAL CONFERENCE ON COMPUTER VISION, VOLS 1-6, : 2641-2648 2007

Malcolm, J;Rathi, Y;Tannenbaum, A, Multi-object tracking through clutter using graph cuts, "OCT 14-21, 2007", 2007 IEEE 11TH INTERNATIONAL CONFERENCE ON COMPUTER VISION, VOLS 1-6, : 2726-2730 2007

Malcolm, J;Rathi, Y;Tannenbaum, A, Label space: A multi-object shape representation, "APR 07-09, 2008", COMBINATORIAL IMAGE ANALYSIS, 4958: 185-196 2008

Malcolm, J;Rathi, Y;Tannenbaum, A, Graph cut segmentation with nonlinear shape priors, "SEP 16-19, 2007", 2007 IEEE INTERNATIONAL CONFERENCE ON IMAGE PROCESSING, VOLS 1-7, : 2061-2064 2007

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Le Faucheur, X;Vidakovic, B;Tannenbaum, A, Bayesian spherical wavelet shrinkage: Applications to shape analysis - art. no. 67630G, "SEP 11-12, 2007", WAVELET APPLICATIONS IN INDUSTRIAL PROCESSING V, 6763: G7630-G7630 2007

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- Dambreville, S;Niethammer, M;Yezzi, A;Tannenbaum, A, A variational segmentation framework using active contours and thresholding, "AUG 20-22, 2007", PROCEEDINGS OF THE NINTH IASTED INTERNATIONAL CONFERENCE ON SIGNAL AND IMAGE PROCESSING, : 185-189 2007
- Rathi, Y;Michailovich, O;Malcolm, J;Tannenbaum, A, Seeing the unseen: Segmenting with distributions, "AUG 14-16, 2006", Proceedings of the Eighth IASTED International Conference on Signal and Image Processing, : 118-122 2006
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- Rathi, Y;Olver, P;Sapiro, G;Tannenbaum, A, Affine invariant surface evolutions for 3D image segmentation - art. no. 606401, "JAN 16-18, 2006", Image Processing: Algorithms and Systems, Neural Networks, and Machine Learning, 6064: 6401-6401 2006

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Szymczak, A;Tannenbaum, A;Mischaikow, K, Coronary vessel cores from 3D imagery: a topological approach, "FEB 15-17, 2005", Medical Imaging 2005: Image Processing, Pt 1-3, 5747: 505-513 Part 1-3 2005

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Karasev, P;Malcolm, J;Tannenbaum, A, KERNEL-BASED HIGH-DIMENSIONAL HISTOGRAM ESTIMATION FOR VISUAL TRACKING, "OCT 12-15, 2008", 2008 15TH IEEE INTERNATIONAL CONFERENCE ON IMAGE PROCESSING, VOLS 1-5, : 2728-2731 2008

#### **Categories for which nothing is reported:**

Organizational Partners

Any Product

Contributions: To Any Human Resource Development

Contributions: To Any Beyond Science and Engineering